MASTER OF SCIENCE
IN
MECHANICAL ENGINEERING

EFFECT OF BISMUTH OXIDE AS A LIQUID PHASE SINTERING AID ON THE DENSIFICATION OF ALUMINA POWDER

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The effect of a liquid forming additive on the densification of ceramic powders is studied. A suitable model system of Al_2O_3-Bi_2O_3 is chosen because of favorable properties for liquid phase sintering and its ability to be processed under atmospheric conditions. Samples of solution deagglomerated slip cast powder compacts are prepared and characterized by x-ray diffraction and scanning electron microscopy. Tests to determine the ability of the system to undergo liquid phase sintering are studied. Problems associated with this manufacturing process are identified and recommendations for future studies are suggested.

DoD KEY TECHNOLOGY AREAS: Materials, Processes, and Structures, Manufacturing Science and Technology (MS&T)

KEYWORDS: Liquid Phase Sintering, LPS, Alumina, Al_2O_3, Bi_2O_3, Bismuth Oxide, Ceramic Powder Processing, Slip Casting, Sintering Aids

A COMPUTER SIMULATION APPROACH TO THE STUDY OF EFFECTS OF DECK SURFACE COMPLIANCE ON INITIAL IMPACT IMPULSE FORCES IN HUMAN GAIT

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The Navy's leadership is looking at improving quality of life and reducing long term health problems through the reduction of knee disorders. One proposal for reducing knee disorders is to install more compliant decking. The goal of this thesis is to develop a computer model of the human gait that estimates the transarticulation forces in the knee during walking on various surfaces. This model can be used to evaluate the reduction of the heel strike forces during walking when deck surface modifications are made. Previous analytical and computer models of the human gait are reviewed. The major contribution of this thesis is a detailed dynamic model of foot-ground interaction during the initial phase of load bearing in human gait.

DoD KEY TECHNOLOGY AREAS: Biomedical, Computing and Software, Manpower, Personnel, and Training, Surface/Under Surface Vehicles - Ships and Watercraft, Modeling and Simulation

KEYWORDS: Human Gait, Computer Model, Simulation, Deck Surface Compliance, Ground Reaction Forces, Dynamics

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MICROMECHANICAL STUDY OF INTERFACE STRESS IN A FIBER-REINFORCED COMPOSITE UNDER TRANSVERSE LOADING USING BOUNDARY ELEMENT METHOD

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Composite materials are involving in engineering applications at a growing speed, due to their stiffer, stronger and lighter properties. This growth requires fast and powerful numerical methods like Boundary Element Method (BEM), and Finite Element Method (FEM). BEM has become popular especially in the last decade due to its advantage of requiring less computation time for the same accuracy. The objective of this study is, by using Boundary Element Method, to examine different shapes of reinforcement elements under unit displacement boundary conditions in transversal direction and at perfect interfacial bonding. The stress variations along the interface of the matrix and reinforcing material, effective elastic modulus of composites were studied due to different shapes and different volume fractions of reinforcement elements. These calculations were made for both the internal Representative Volume Element (RVE), and boundary RVE, which are the internal and boundary cells of composite material respectively. Finally, using an appropriate failure criterion, the failures of different shapes were examined and also the effective elastic modulus variations of the shapes during the progress of the failure for both internal and boundary RVE were studied.

DoD KEY TECHNOLOGY AREA: Materials, Processes, and Structures

KEYWORDS : Micro Mechanics, Interface, Boundary Element Method, Debonding

OPTIMAL FAULT DETECTION AND RESOLUTION DURING MANEUVERING FOR AUTONOMOUS UNDERWATER VEHICLES

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In order to increase robustness, reliability, and mission success rate, autonomous vehicles must detect debilitating system control faults. Prior model-based observer design for 21UUV was analyzed using actual vehicle sensor data. It was shown, based on experimental response, that residual generation during maneuvering was too excessive to detect manually implemented faults. Optimization of vehicle hydrodynamic coefficients in the model significantly decreased maneuvering residuals, but did not allow for adequate fault detection. Kalman filtering techniques were used to improve residual reduction during maneuvering and increase residual generation during fault conditions. Optimization of the Kalman filter's system noise matrix, measurement noise matrix, and input gain scalar multiplier produced fault resolution which allowed for accurate detection of faults of relatively minor magnitude within minimal time constraints.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles - Ships and Watercraft, Modeling and Simulation, Other (Autonomous Systems, Robotics)

KEYWORDS: Autonomous Underwater Vehicles, Robotics, Robust Fault Detection, Reliable Fault Sensitivity, Extended Kalman Filtering, Optimization

PROPAGATION OF FIRE GENERATED SMOKE IN SHIPBOARD SPACES

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The propagation of fire generated smoke into a shipboard space has been computationally modeled using a commercial code generated by Computational Fluid Dynamics Research Corporation (CFDRC). This study was based on space 01-163-2-L of an Arleigh Burke Class Flight IIA Destroyer. However, with changes, the model can be reconfigured to represent other shipboard spaces. Multiple smoke scenarios are applied to the space. For all scenarios, the inlet used is forward water tight door. Smoke enters the upper half of the door, while air enters through the bottom half. The temperature of the inlet fluids is altered to observe its effect on propagation. In the last scenario, the floor temperature is isothermally held at 1200 K to simulate a fire in the space below. The results of this scenario shows that extreme temperatures of adjacent spaces has minimal effect on propagation. The overall goal of this study is to show how computational methods can be used to model propagation of smoke in shipboard spaces.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Convection, Smoke Modeling, Computational Fluid Dynamics

THE ROLE OF VISCOUS FINGERING IN THE SEPARATION MECHANICS OF THIN INTERFACIAL LIQUID LAYERS

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The mechanics of separation of a thin interfacial liquid layer trapped between two parallel surfaces was studied in a controlled manner. Different liquid viscosities, layer thicknesses and separation velocities were used to investigate the extensional behavior and determine its dependence on viscous fingering, and capillary number. Force, displacement and time data have been recorded for all experimental runs. Qualitative visual data have also been recorded to corroborate the trends in the onset of viscous fingering based on a simple interfacial stability analysis. The quantitative data has been used to generate force-displacement plots of the separation. The results of this work provide useful fundamental insight into the mechanics of this novel problem.

DoD KEY TECHNOLOGY AREAS: Material, Processes, and Structures, Other (Civil Engineering)

KEYWORDS: Thin Interfacial Liquid Layers, Capillary Number, Surface Tension, Viscous Fingering, Saffman Instability, Hele-Shaw Flow